Eur J Vasc Endovasc Surg (2008) **36**, 182–188

In-situ Revascularisation for Patients with Aortic Graft Infection: A Single Centre Experience with Silver Coated Polyester Grafts

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Submitted 27 September 2007; accepted 26 February 2008
Available online 25 April 2008

KEYWORDS
Aortic graft infection;
Silver coated graft

Abstract *Objective:* The aim of this study was to evaluate the early and mid term outcome of patients with aortic graft infection who underwent in-situ revascularisation with a silver coated prosthesis.
Material: From January 2000 to December 2006, 24 consecutive patients (22 male, 2 female) with mean age 67 years were prospectively entered in this study of aortic graft infection at our single centre. Infection was managed with either total ($n = 19$) or partial ($n = 5$) excision of the infected graft and in- situ reconstruction with a silver coated prosthesis, Inter Gard Silver (IGSG).
Methods: The primary endpoint was recurrence of infection. Secondary endpoints were early and late mortality, peri-operative morbidity, primary graft patency, major amputation rates and patient survival.
Results: Fourteen patients had a primary graft infection, however 10 of 24 patients had graft infection secondary to aorto digestive ($n = 9$) or aorto urinary ($n = 1$) tract fistulas. Bacteriological cultures were negative in 8 (33%) patients. Most organisms cultivated where virulent and the majority of graft infections were polymicrobial (71%). Silver grafts were placed emergently in 6 (25%) patients. Mean follow up 32.5 ± 31.0 months (range 2–78 months).

Peri-operative morbidity and mortality were 46% and 21% respectively. Early interventions occurred in 6 (25%) patients and late secondary intervention were required in 3 (15.7%), caused by silver graft reinfection. The late mortality was 26%.
Conclusion: In-situ reconstruction with the silver graft confirms similarity with other modalities. The greatest advantage for the silver graft is its ease of use but the risk of reinfection remains significant.

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1078-5884/$34
doi:10.1016/j.ejvs.2008.02.013

Introduction

Aortic graft infection is a life-threatening complication that occurs in 1% to 2% of patients who undergo conventional aortic surgery.[1,2] Extra-anatomic bypass (EAB) has long been the gold standard for such patients.[3] However, owing to the drawbacks of EAB,[4–7] in-situ revascularization after excision of the infected prosthesis has been proposed for patients with aortic graft infection. Controversy continues concerning the optimal substitute material to be used after aortic graft removal. Various substitute materials such as autogenous veins, cryopreserved arterial allograft, rifampicin bonded prostheses and silver-coated prostheses have all been tested.[4–10] In our initial experience, 11 patients with an aortic graft infection plus an additional 16 patients from a multicentre study[10] were managed with a silver-coated prosthesis (Inter Gard Silver prosthesis (IGSG); InterVascular, La Ciotat, France). Our early promising results with silver-coated grafts led us to adopt them for routine use in all of our patients presenting with aortic graft infection.

The bacteriostatic properties of silver salts are well-recognised, and their efficacy as an antimicrobial agent when incorporated with medical devices has been reported extensively.[11–16] The IGSG is a woven or knitted polyester graft coated with type I bovine collagen and silver acetate. Approved for use in Europe in 1999, the IGSG was the first antimicrobial prosthesis to obtain the CE mark enabling the product to be sold in the European Union. However, despite increasing use of the IGSG, little data is available concerning the efficacy of the silver ions on the graft over time or the long-term results of silver-coated prosthetic grafts in patients with an aortic graft infection. The reasons for this lack of information include rarity of such infections, the inability to randomise treatment because of surgical preference or patient condition and lack of availability of all grafts especially in emergency situations.

The purpose of this study, conducted at a single university hospital, was to analyse the outcome of patients with an aortic graft infection who underwent in-situ revascularisation with a silver-coated prosthesis in order to increase our knowledge concerning the true utility of this type of prosthesis.

Material and Methods

All patients ($n = 24$) admitted to our hospital for an aortic graft infection between January 1, 2000 and December 31, 2006 were enrolled in this prospective study following approval of the local Ethics Committee. During the study period, the diagnosis of aortic graft infection was based on clinical examination and CT findings. Preoperative conventional angiography was performed only when clinically appropriate. Patients with aortic graft infection due to an aorto-digestive or aorto-urinary tract fistula were classified as having secondary aortic graft infection. All other patients were classed as having a primary graft infection (PGI). Whenever possible, specimens for microbiological culture, including specimens of any external discharges, were obtained prior to surgery. Appropriate antibiotic therapy was then initiated in these patients prior to surgery. If no specimens were obtained, broad spectrum antibiotic therapy, particularly vancomycin, was administered peri-operatively.

Our surgical policy for treatment of patients with aortic graft infection was standardised on January 1, 2000. Since then, our standard procedure comprises excision of the infected graft and in-situ replacement (ISR) with an IGSG.

Total graft excision was the rule when infection involved the entire prosthesis. Partial graft excision was performed only when infection was limited to the graft body or to a single limb provided that the remainder of the graft was well encapsulated. During surgery, additional specimens were taken for bacteriological analysis and all excised prosthetic grafts were sent for culture. All patients underwent complete debridement of surrounding tissues followed by irrigation of the operative fields with liberal amounts of standard povidone-iodine solution followed by in-situ reconstruction with the IGSG.

The prosthetic graft was covered with an omental flap whenever possible. None of the IGSG used in this study was pre-soaked with rifampicin. We have defined the early, mid and late post operative periods as $<$30 days, $<$12 months and $>$12 months respectively.

Following surgery, all patients received peri-procedural intravenous antibiotics. Oral antibiotics were continued for 3–6 months, depending on the virulence of the specific organisms cultured. The virulent organisms cultured included gram-negative, anaerobic, methicillin-resistant Staphylococcus, fungal, and polymicrobial species, including coagulase-negative Staphylococcus.

Serial CT scans of the in-situ graft were obtained before discharge from the hospital and then at 3 and 6 months post surgery, and thereafter bi-annually. We have follow-up data for all our patients up to December 2006.

The primary endpoint was recurrence of infection. Secondary endpoints were early and late mortality, peri-operative morbidity, primary graft patency, major amputation rates and patient survival.

Univariate analysis was performed for prognostic factors associated with a poor outcome. Pearson's chi-square or Fisher's exact test were used for analysis of categorical variables. A value of $p < 0.05$ was considered statistically significant. The Kaplan-Meier method was used to analyse patient survival and freedom from reinfection.

Results

Twenty-four consecutive patients were admitted to our department during the study period for aortic graft infection and were enrolled in the trial. Mean $\pm$ standard deviation (SD) follow-up was 32.5 ± 31.0 months with a range between 2 and 78 months. The mean $\pm$ SD age of these 22 (92%) males and 2 females was 67 ± 9 years ranging between 44 and 87 years. Present or past cigarette smokers accounted for 87% of patients in the study with a mean $\pm$ SD of $53 + 27$ pack-years. Other pertinent risk factors included hypertension (54%), coronary artery disease (50%), chronic obstructive pulmonary disease (25%), hyperlipidemia (21%), renal failure defined as creatinin concentration $>$ 3.0 mg/dl (8%), risk factors for infection (21%), diabetes mellitus (17%), malnutrition (8%), and immuno compromised state (8%).

Initial graft placement was prompted by occlusive disease in 14 patients (58%) and aneurismal disease in 10 patients (42%). The mean ± SD interval between initial prosthetic graft insertion and diagnosis of graft infection was 73 ± 64 months, ranging between 1 and 264 months. The bypass configuration of these infected grafts was aorto-femoral, aorto-aortic, and aorto-iliac in 14 (58%), 3 (13%) and 7 (29%) patients respectively. All of the 24 infected prosthetic grafts replaced were of polyester construction. Clinical symptoms at presentation with infection are shown in Table 1 and CT findings listed in Table 2. Infection of the 5 proximal anastomotic aneurysms were related in 3 patients to graft duodenal fistula through rupture of a proximal anastomotic aneurysm, and in 2 further patients to distal anastomotic pseudo aneurysms with frank purulence around the graft.

Aortic reconstruction of the infected graft was performed as an elective surgical procedure in 18 (75%) patients with the remaining 6 (25%) performed as emergency procedure due to gastrointestinal bleeding with shock ($n = 3$) or rupture of a proximal anastomotic aneurysm ($n = 3$). The mean ± SD operative time was 320 ± 120 min., ranging between 110 and 480 min, whilst the mean ± SD blood transfusion was 3.8 units ranging from 1 to 11 units.

The peri-operative mortality rate was 21%, 5 of 24 patients. The main causes of death were myocardial infarction ($n = 2$), pulmonary infection ($n = 1$), and multiple organ failure ($n = 2$). The operative mortality after emergency aortic reconstruction was 67% versus 6% when reconstruction was performed as an elective procedure ($P < 0.05$).

While the majority 14 (58%) patients had a PGI, 10 (42%) had a graft infection secondary to a graft sigmoid fistula (GSF) ($n = 2$), aorto-iliac urinary tract fistula ($n = 1$) and graft duodenal fistula (GDF) ($n = 7$). Two patients with GSF presented with signs of peritonitis (Table 1) caused by erosion of the sigmoid colon by the prosthesis ($n = 1$) and as result of prostatectomy for cancer ($n = 1$). Sigmoidectomy with a diverting colostomy and partial graft excision limited to a single limb was successful for both of these patients. The patient with an aorto-iliac urinary tract fistula after cystectomy had an uneventful recovery after ureteral drainage by a double-J catheter and limb resection of the infected graft.

Table 1 Clinical presentation in 24 patients with an infected aortic graft

Symptoms	N	%
Sepsis (fever, leukocytosis, bacteremia)	9	37
Inguinal abscess	8	33
Shock with severe gastrointestinal bleeding or rupture of false aneurysm	6	25
Abdominal or back pain	6	25
Urinary fistula	1	4
Anorexia and weight loss	2	8
Foot abscess	1	4
Lower limb ischemia	1	4
Peritonitis	2	8

Table 2 CT findings

CT finding	N (%)
Perigraft fluid	7 (29)
Perigraft fluid with an air/fluid interface	7 (29)
Retroperiotoneal abscess	10 (42)
Ureterohydronephrosis	4 (17)
Proximal anastomotic false aneurysm	5 (21)
Distal anastomotic pseudoaneurysm	3 (8)

Seven patients had GDF comprising duodenal erosion of the graft ($n = 4$) and communication at the level of a proximal aneurysm ($n = 3$). Table 3 lists the main features of these 7 GDF patients. GDFs were treated by gastro-jejunostomy and exclusion of the fistula in one patient, and by duodenorrhaphy in 5 patients. Segmental duodenal resection with end-to-end anastomosis was required for the other patient due to severe damage to the duodenal wall. Two patients underwent early repeat operation at 7 and 15 days for duodenal leakage after simple primary duodenal closure. One patient died on Day 50 after gastro-jejunostomy from multi-organ failure whilst the other had an uneventful recovery after duodeno-jejunostomy. The operative mortality of patients with GDF was 57% compared with 6% for those without ($p < 0.05$). Operative mortality was 100% in the 3 patients with GDF treated emergently.

Complete graft infection was observed in 19 (79%) patients with 5 aorto iliac and 14 aorto femoral bypasses. They all underwent total graft excision and in-situ replacement with an IGSG. The graft was covered with a pedicled omentoplasty in 12 (63% of the 19 patients). The infection was limited to a segment of the graft in 5 (21%) patients, the body of the graft in 2 patients, and one limb in 3 patients with the remainder of the prosthesis being well encapsulated in all cases. Each of these 5 patients underwent in-situ replacement with a segment of IGSG combined with an omental flap.

Table 3 Summary of the 7 graft duodenal fistula

Characteristics of the 7 patients	N (%)
Symptoms	
shock with severe gastro intestinal bleeding	3 (42)
sepsis	2 (29)
abdominal pain	2 (29)
Operative mortality (≤J30)	4 (57)*
Early reoperation (duodenal leakage)	2 (29)**
Late reoperation (reinfection due to recurrence of GDF)	1 (14)***
Secondary mortality (> J30)	2 (33)
Bacteriological culture	
sterile	4 (57)
polymicrobial	3 (43)
presence of fungus	2 (29)

* 80% of operative mortality.
** 33% of early reoperation.
*** 33% of recurrence of graft infection.

The majority of the graft infections were polymicrobial (71%). The monomicrobial infections were typically due to gram-positive species. Table 4 lists the various organisms cultured. Bacteriological cultures were negative in 8 (33%) patients. The clinical presentation in these patients was an inguinal abscess ($n = 3$), a urinary fistula ($n = 1$), a GDF with shock ($n = 2$) and gastrointestinal bleeding ($n = 2$). CT demonstrated perigraft fluid ($n = 4$), perigraft fluid with an air interface ($n = 3$), a retroperitoneal abscess ($n = 4$) and a proximal anastomotic false aneurysm ($n = 3$). Virulent organisms were cultured from 4 (80%) of 5 patients who died with fungal infection noted in 3 (60%) and Clostridium perfringens in 1 (20%). The fifth culture remained sterile. Virulent organisms were identified in 9 (47%) of the 19 surviving patients which was not statistically significantly different when compared with those patients who died ($p = 0.33$).

A total of 13 non fatal peri-operative complications occurred in 11 (46%) patients (Table 5). Early reoperations were required in 6 (25%) of patients (Table 5). Two patients underwent early repeat operation for duodenal leakage. Two other patients presented with femoral anastomotic breakdown, postoperative day 2 and 6. The aortic graft infection at the time of replacement was thought to be limited to the body of the graft and treatment comprised segmental replacement with IGSG and conservation of the limb and the femoral anastomosis of the initial prosthesis. Anastomotic rupture was caused by incomplete resection of the initial infected prosthesis proven by the fact that the IGSG was not reinfected. The other two reinterventions were prompted by acute limb ischemia with 1 patient undergoing successful femoropopliteal bypass and the other tibial amputation.

Late secondary procedures were required in 3 patients. The first patient presented a unilateral femoral false aneurysm with a periprosthetic collection along the distal part of one limb after 56 months. Repeat graft limb replacement with an IGSG segment proved successful after a follow-up of 14 months. The second patient presented with a bilateral femoral false aneurysm. Reinfection of the entire aortic graft, characterised by a frank purulence collection along the entire length of the IGSG, was observed at 60 months. Insertion of a new IGSG has been successful to date with a follow-up of 13 months. Bacteriologic analysis of the purulent discharge was negative for both of these patients. The third patient presented with a recurrent GDF 15 months after the initial aortic graft replacement. This was considered a late infection despite the evidence of IGSG reinfection without peri-prosthetic collection or peritoneal abscess. This patient was reoperated and died in the postoperative period of myocardial infarction. Reinfection of the IGSG used for replacement occurred in 3 (15.7%) of19 surviving patients (Table 6). Freedom from recurrent infection was 100% and 92.3% at 1 and 3 years respectively (Fig. 1). There were no instances of late graft occlusion. Primary and secondary patency rates were 91.7% and 95.8% at 1 and 3 years respectively. Five (26%) of 19 patients died in the late post-operative period. Death was due to multiorgan failure ($n = 1$), myocardial infarction ($n = 2$) and cancer ($n = 2$). Patient survival rate was 75% at 1 year and 62% at 3 years (Fig. 2).

Table 4 Bacteriological reports for patients with aortic graft infection

Organism cultured	N (% of the total of the 24 patients)
Gram-positive	
Coagulase-negative Staphylococcus	6 (26)
Enterococcus	5 (22)
Methicillin-resistant Staphylococcus aureus (MRSA)	4 (17)
Streptococcus viridans	4 (17)
Gram-negative	
Escherichia coli	3 (13)
Pseudomonas aeruginosa	2 (9)
Klebsiella	2 (9)
Enterobacter	2 (9)
Salmonella	2 (9)
Fungus	5 (21)
Anaerobes	1 (4)

Table 5 Peri-operative complications

Complication	N (%)
Partially resolved sciatic and femoral nerve palsy	2 (8)
Iliac venous thrombosis	2 (8)
Femoral anastomotic breakdown	2 (8)
Bacteremia	1 (4)
Acute limb ischemia due to graft occlusion	2 (8)
Prolonged bowel ileus	2 (8)
Duodenal leakage	2 (8)

Discussion

A number of the patients in this study were previously reported in a multicentre study.[10] Long-term follow-up was complete for the 11 patients of our centre who were included in this earlier study. Despite our efforts, it proved impossible to obtain the late follow-up data for all patients from the other centres. This problem with multicentre studies highlights the importance of our single-centre experience with 24 consecutive patients who were all closely followed-up. Furthermore, literature is scant on this treatment option for aortic graft infection. Several reasons explain the paucity of reports. Primarily, aortic graft infections are fortunately infrequent. Secondly, individual physicians and/or centres have too few cases to publish and do not all use the same treatment protocol. Finally, no consensus exists on treatment modalities. Our study is unique as there are no previous reports in the literature which describes the use of a specific in-situ treatment based on placement of IGSG.

The primary end-point of this study was the recurrence of infection. No early recurrent IGSG infection occurred in our study, but 3 patients (15.7%) developed a late reinfection diagnosed after 15, 56 and 60 months follow-up. This highlights the continued risk of recurrence of infection with the length of follow-up. In this study 3

Table 6 Treatment of aortic graft infections: Results of contemporary studies**

Author (year)	*n* (follow-up)	Operative mortality n (%)	Operative morbidity n (%) MLS	Early occlusion n (%)	Amputation n (%)	Reinfection n (%)	Late occlusion n (%)	Dilatation n (%)	Rupture n (%)	Late death n (%)
Extra-anatomic reconstruction										
Seeger et al[7] (2000)	36 (32)	4 (11)	15 (42) (NA)	2 (6)	4 (11)	1 (4)	12 (35)	0	1 (4)	3 (12) 1 (4)*
Oderich et al[6] (2006)	43 (40)	5 (12)	29 (67) (21 +/− 17)	NA	4 (9.3)	5 (11.6)	17 (39)	0	4 (9.3)	19 (44) NA*
In-situ reconstruction										
Allografts, Kieffer et al[9] (2004)	179 (46)	36 (20)	36 (20) (NA)	2 (1)	1 (0.5)	1 (0.7)	46 (32)	25 (17)	3 (2)	37 (26) 3 (2)*
Autogenous vein, Clagett et al[4,5] (2005)	242 (56)	NA	NA	NA	0.4	2.4	3.8	0	0.8	NA
Rifampin-bonded prosthesis, Oderich et al[6] (2006)	52 (40)	4(8)	23 (44) (NA)	3 (6)	0	6 (11.5)	6 (11.5)	0	0	10 (29) 0*
Silver prosthesis, Current series	24 (32.5)	5 (21)	11 (46) (23 +/− 19)	2 (8)	1 (4)	3 (15.7)	0	0	0	5 (26) 1 (5)*

* late procedure-related death; NA: not available; MLS: median length of stay.

** our results were compared with other reports on alternative treatment modalities for aortic graft infection, extra-anatomic bypass, in-situ reconstruction with an autogenous vein, cryopreserved allograft and rifampicin-bonded prosthesis. Appropriate contemporary single centre studies which were published after 1990 and included more than 20 cases with a mean follow-up of > 24 months were selected for comparison.

(15.7%) patients were diagnosed with a graft reinfection after a mean follow-up of 44 months. An earlier study[10] cited only 1 such case (3.7%) of reinfection after a follow-up of 17 months. Various risk factors for recurrent graft infection[5,17] were present in these 3 patients (GDF, $n = 1$; large perigraft abscess, $n = 0$, negative bacteriological culture, $n = 2$; virulent organisms, $n = 2$, segmental infected graft excision, $n = 2$; no omentoplasty, $n = 2$, factors of increased susceptibility to infection, $n = 0$). Late infection cannot be linked to infection type or highly virulent organisms.

Instinct suggests removal of an infected graft in its entirety rather than a partial excision. However, operative problems including collateral arteries and salvage, to name but two, may dictate otherwise according to the macroscopic appearance of the graft. Patients ($n = 2$) with femoral anastomotic breakdown, where there was resection of the body of the graft, were cultured positive and polymicrobial with MRSA. The IGSG replacements ($n = 3$) with a single limb were cultured positive in just 1 patient. However, no secondary interventions were necessary in these patients.

Questions remain concerning the resistance to infection of the different grafts used for in-situ reconstruction because few studies have investigated this point.[5,6,8–10,18–20] Autogenous veins and cryopreserved allografts are associated with the lowest rates of reinfection, 2.4% and 0.7% respectively (Table 6). This rate of reinfection is comparable with rifampicin-bonded prostheses and IGSG being 11.5% and 15.7% respectively. The antibacterial activity of the silver or antibiotic-bonded graft over time is probably the key to limitation of late recurrent infection, but none of the currently available impregnated prosthetic grafts

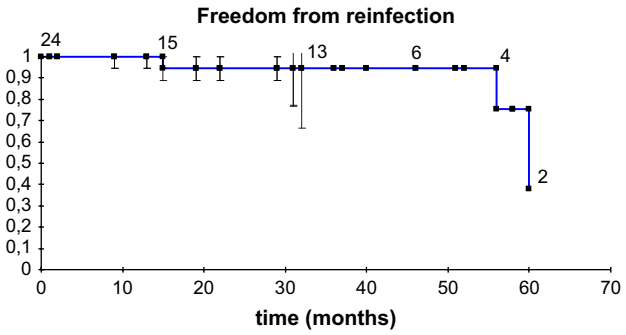

Figure 1 Freedom from recurrent infection (Kaplan-Meier curve).

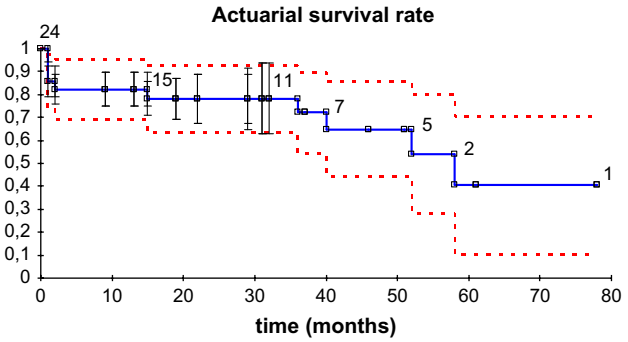

Figure 2 Actuarial survival rate (Kaplan-Meier curve).

offers optimal efficacy. A new polyester silver graft seems promising (B Braun Silver graft, Aesculap AG, Tuttlingen, Germany). The silver fibre sealing technology used for this graft reportedly retains up to 98% of the silver load under laboratory conditions[21] after one year. Publication of clinical studies in human with medium or long-term follow-up is eagerly awaited to determine the efficacy of this new silver graft.

In this study, antibiotics were stopped after 6 months with a late recurrent graft infection of 15.7%. Conversely, Oderich *et al.*[6] reported a late recurrent graft infection rate of 11.5% despite life-long oral antibiotic therapy. Operative morbidity and mortality remained an acceptable 46% and 21% respectively in our overall population and comparable with those reported by other authors for patients treated by extra-anatomic bypass or in-situ reconstruction with other materials (Table 6).[4–7,9,17] These rates appear attributable more to the patients' general condition than to the choice of treatment. In addition, virulent organisms (46%) and especially fungi cultured in cases of graft duodenal fistulas are associated with a tendancy of a higher operative mortality but it was not statistically significant. Our study confirms earlier reports[5,8,9,17] showing that GDF is a strong predictor of morbidity and mortality (Table 3). This was probably related to the fact that 50% of this patient group underwent an emergency procedure without preoperative preparation. Special attention must be paid to the treatment of patients with duodenal fistula, 2 of whom were re-operated for duodenal leakage which resulted in 1 death. This is also true for the technique of pedicled omentoplasty,[6] where the recurrence of GDF resulted in the death of 1 patient where ompentoplasty was not performed.

Treatment of aortic graft infection is changing. Some surgeons are in favour of a conservative approach with the obvious exception of emergency ruptured cases. An increasing number of authors[6,9,10] have broadened the indications of ISR. Others, however, still reserve staged procedures with initial axillo-bi-femoral reconstruction for patients with large perigraft abscesses or graft duodenal fistulas.[6,17] A recent meta-analysis[18] challenged the status of extra-anatomic bypass as the gold standard for treatment of aortic graft infection. After pooling the outcome data for all patients reported in the literature between January 1985 and August 2005, a statistically significant difference was evident in favour of patients treated by ISR with rifampicin-bonded prosthesis, cryopreserved allografts and autogenous veins compared with those treated by extra-anatomic bypass. In-situ reconstruction with a silver graft was not included in this meta-analysis because only one publication[10] was available on this treatment modality. Calculation of event rates for this single study on silver did, however, conclude that, under low virulence conditions, in-situ treatment with silver compared favourably with other in-situ modalities and extra-anatomic bypass. Silver grafts alone have the added advantage that they do not contribute to the increasing resistance of antibiotics and they had a wide activity profile including methicillin-resistant staphylococcus aureus as is not the case with rifampicin-bonded prosthesis.[22]

The various options for in-situ replacement also remain controversial. Autogenous vein is the most effective method to avoid recurrent infection[4,5,8,18] (Table 6). However, in an emergency setting which occurred in 25% of cases in our study, the operative time is an important issue limiting their applicability. Cryopreserved allografts are associated with a low rate of recurrent infection[9,19] (Table 6) and are less complicated to use than autogenous veins but can be problematic for emergent procedures. Graft conditioning in specialized tissue banks, availability of the correct product type compounded by limitations for their distribution and consequently their availability are just a few of the major factors limiting their utility for elective procedures. Moreover, the rates of late occlusion and late dilation, respectively 32% and 17% raise the question of the durability of cryopreserved allografts. Conversely, synthetic prostheses are available in a great variety of types and sizes, are readily available and offer good late patency rates with acceptable long term stability. Compared with cryopreserved allografts, prosthetic grafts rarely lead to late occlusions and there have been no reports cases of late graft dilation or graft rupture (Table 6). Nevertheless, questions remain concerning the resistance to infection of prosthetic grafts, including IGSG, because few studies have investigated the issue.[6,10,17,20]

Conclusion

IGSG appears a reasonable option amongst others for treatment of the serious problem of graft infection with a relatively low rate of secondary procedures. However, the conclusions of our study are limited by the fact that there was no control group treated with an alternative technique as well as by the modest mean ± follow-up of only 32 months. This, however, in the scheme of aortic graft infections publications is not an insignificant consecutive series with one single treatment modality over a 6 year period from a single centre. The greatest advantage of the IGSG is its ease of use, and availability for emergent procedures but the risk of reinfection remains of concern as it does with other modes of treatment.

Acknowledgements

We are very grateful to Brigitte Have and Nancy Reed for the assistance in the preparation of the manuscript.

Conflict of Interest

Dr. O'Connor is a former employee of InterVascular, a Datascope company and is now employed by Cameron Health, San Clemente, California, USA.

Dr. Batt has been paid a consulting fee by Datascope for lectures.

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